Fiber-delivery system for high-power UV-LEDs

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Content

- Introduction
- Imaging system for UV-LEDs and optical fibers incl. parameters
- Components / test samples
- Experimental results:
  - Coupling efficiency
  - Basic transmission
  - Transmission changes during UV-irradation
- Comparison of different FO-systems
- Summary

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Introduction of my group

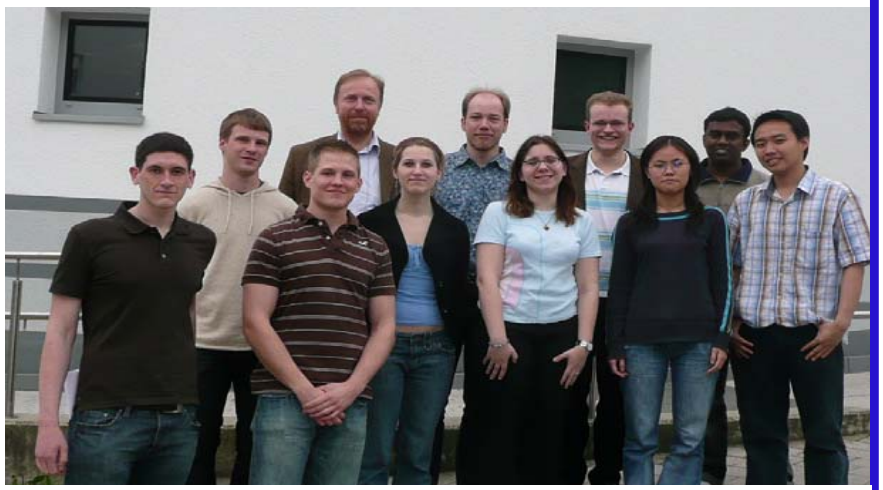
Laboratory of Optical Communications and Waveguides

Characterisation of multimode-fibers,
specialty fibers/waveguides and fiber bundles
Fiber development for UV-region (non telecom)

Development of suitable measurement techniques
Development of fiber-optic systems,
plus optimisation/adjustment of components

Mobile sensor systems for gas-
and liquid analyses

Quality control for externals
Characterisation of special
assemblies for R&D



Cooperation with Prof. Behler
(Industrial Laser Applications)

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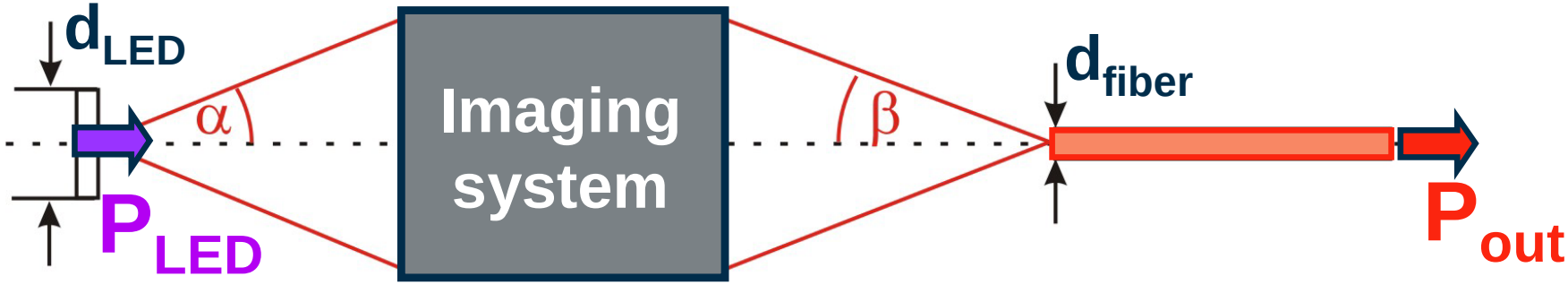
Overview about total system
including parameters of components

UV-LED

Optical fiber, fiber bundle



Output power
Wavelength
Farfield angle

Aspect ratio
Ratio of NA

Output power:
- **Coupling efficiency**
- **Basic transmission**
- **UV-damage/annealing**

Numerical aperture (NA)

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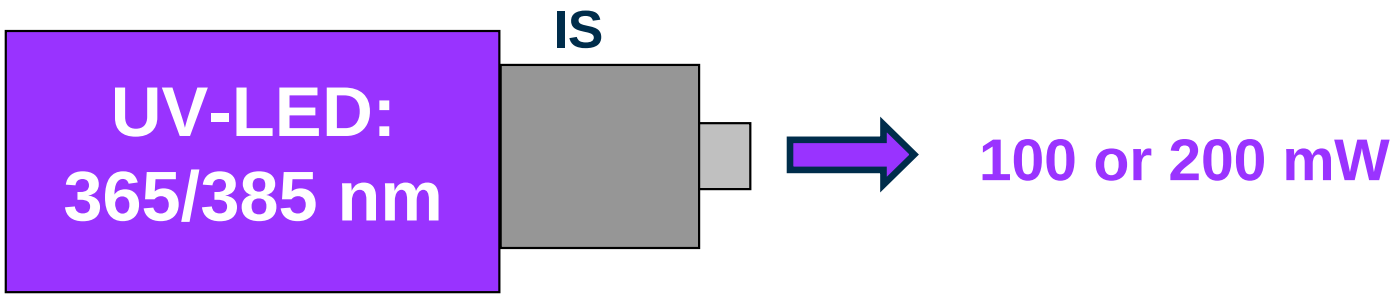
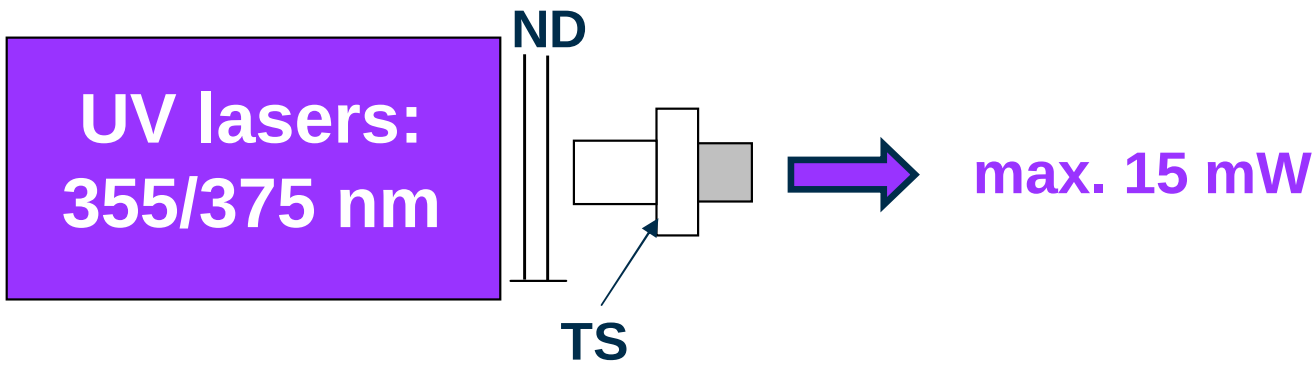
Components: light sources



For damaging and reference studies, only



plus Xenon-lamp, mercury lamp, deuterium-lamp

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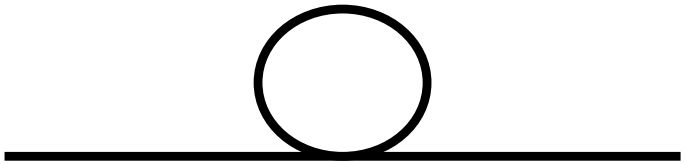
IS: simulated and improved imaging system
ND: Neutral Density Filter Holder
TS: XYZ-fiber translation stage

Fibers under test



All-silica:	**600 µm, NA=0.22**
POF:	**250 µm, NA=0.50**
POF:	**1000 µm, NA=0.50**
POF:	**2000 µm, NA=0.50**
PCSF:	**200 µm, NA=0.35**
PCSF:	**600 µm, NA=0.35**
PCSF:	**400 µm, NA=0.48**
PCSF-bundle:	**7x600 µm, NA=0.36**

Options (with UV-LEDs not tested, yet)

- **Microstructured fibers**
- **Glass fiber bundles**

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Targets / results

IS coupling efficiency:

- Size of LED-chip, simulation and experimentals
- fibers vs. bundles

Transmission of optical fibers:

- Basic attenuation before irradiation
- Spectral changes during UV-irradation (including test system)

Numerical aperture measureable (not shown here):

- Test system for thick-core fibers and fiber-bundles developed and characterized

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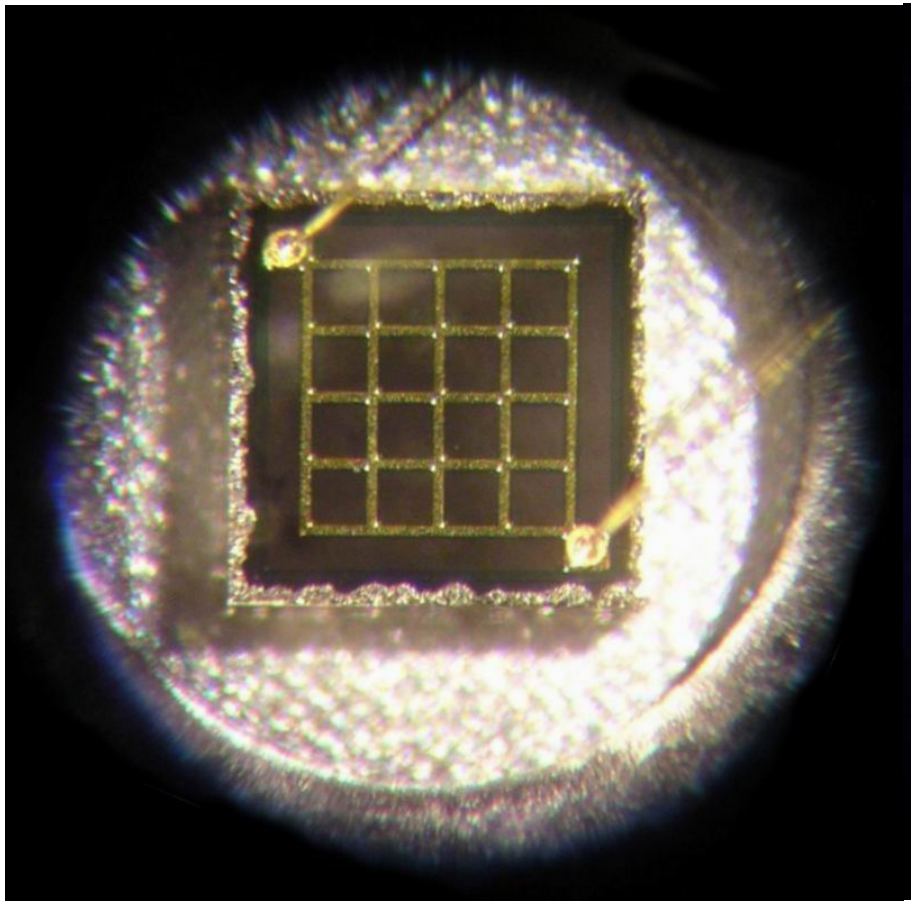
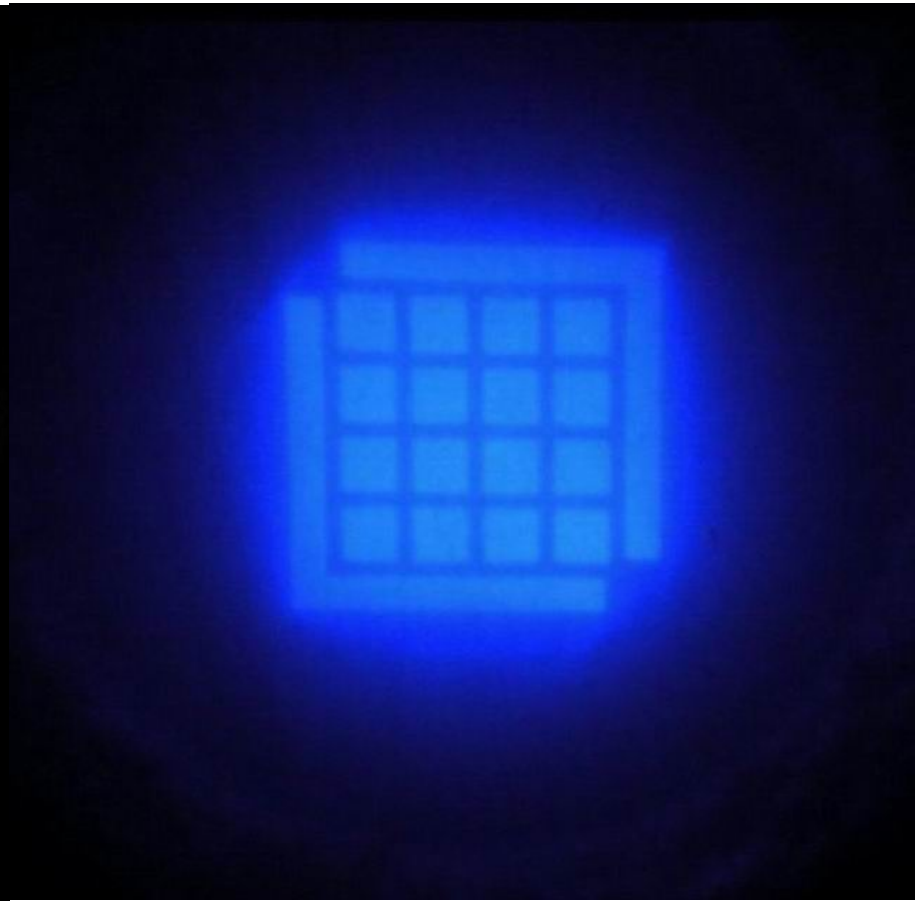
Photograph of the LED-chip

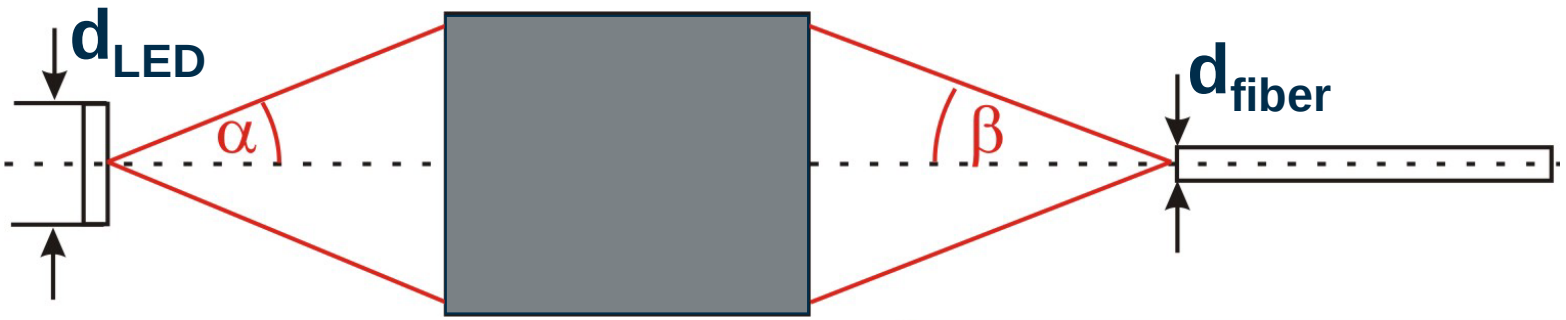
Incident top lighting

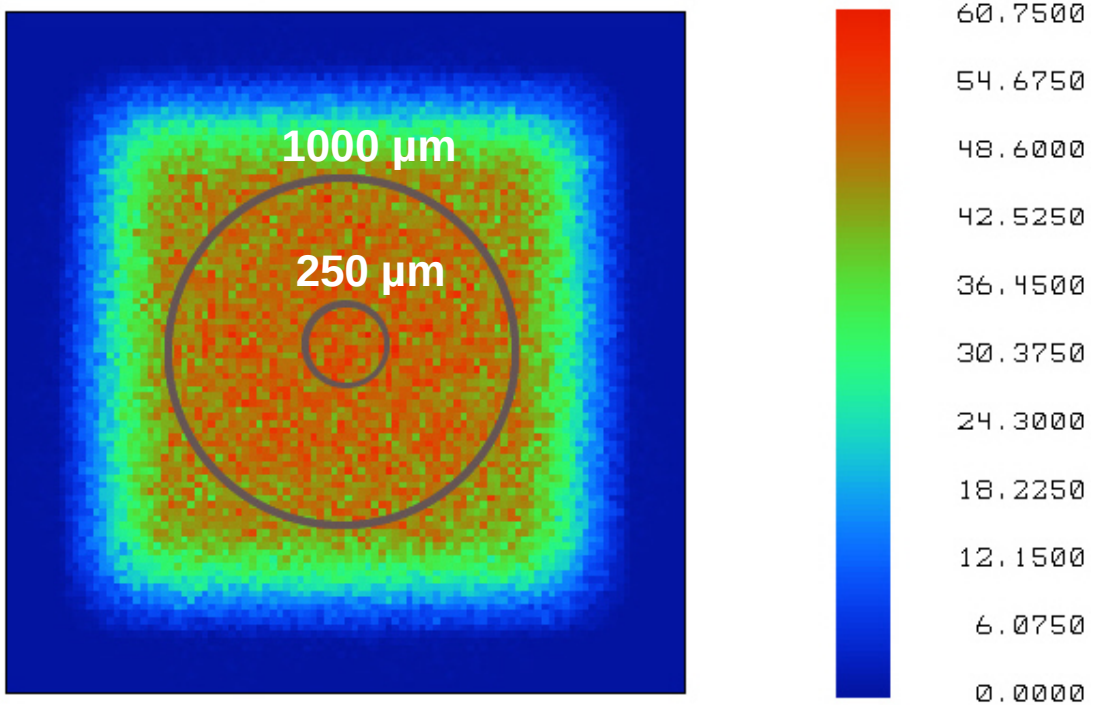


Emitting surface imaged on a white screen



Imaging system: coupling efficiency





Simulation and optimization of lens-collimation system by ray-tracing (with > 100,000 rays)

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Output power of total system,
using mono-fibers only

	Power [mW]	Efficiency [%]
UV-LED	105 (200)	100.0
Imaging-system	95 (175)	

	Efficiency [%] of (total) output power
POF 2000 µm	64.8
POF 1000 µm	32.4
POF 250 µm	4.8
PCSF 200 µm	2.5
AS-fiber 600 µm	5.0

Remarks:

including fiber-losses (1 m fiber) no additional losses

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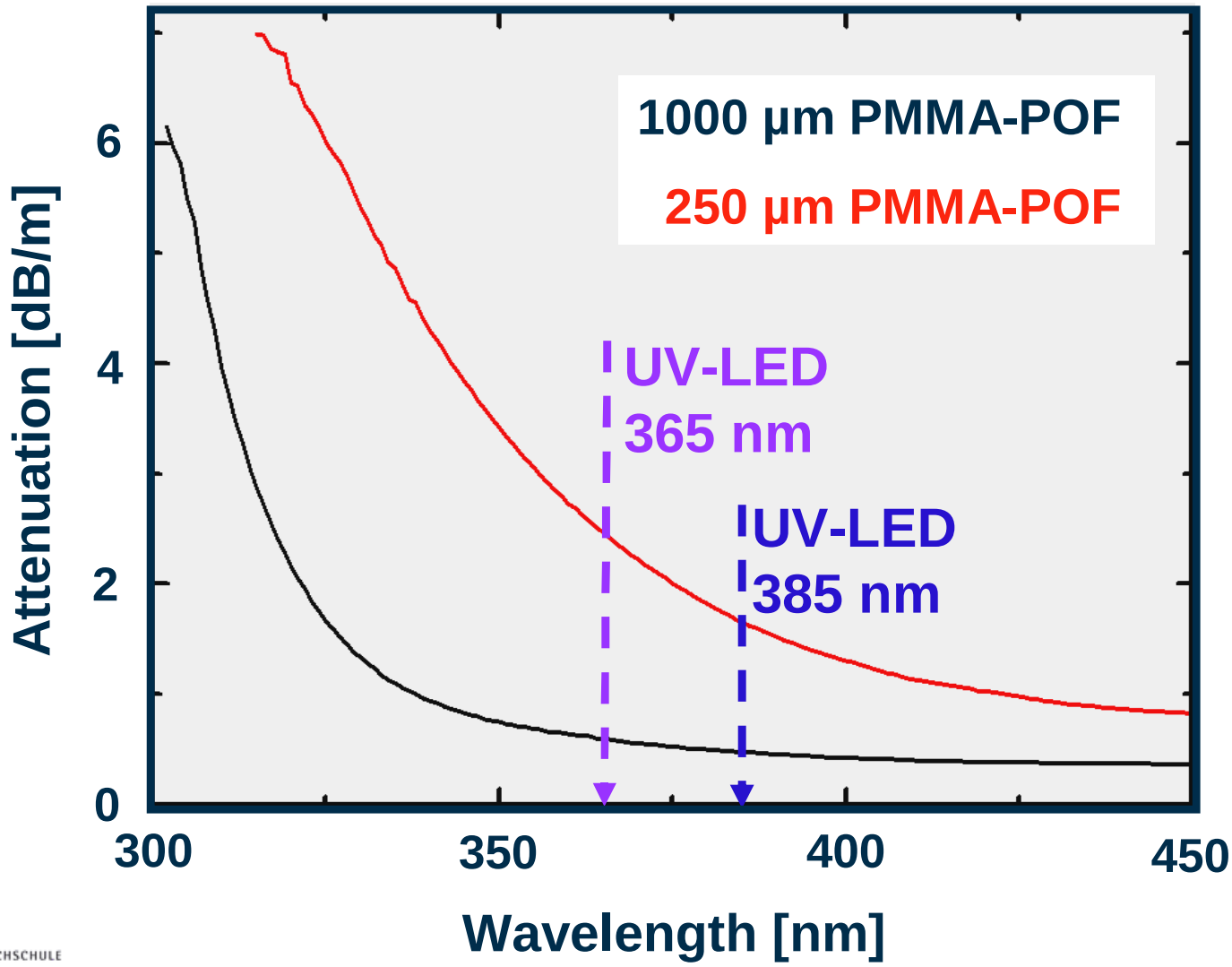
Spectral attenuation of UV-optimized PMMA-POF



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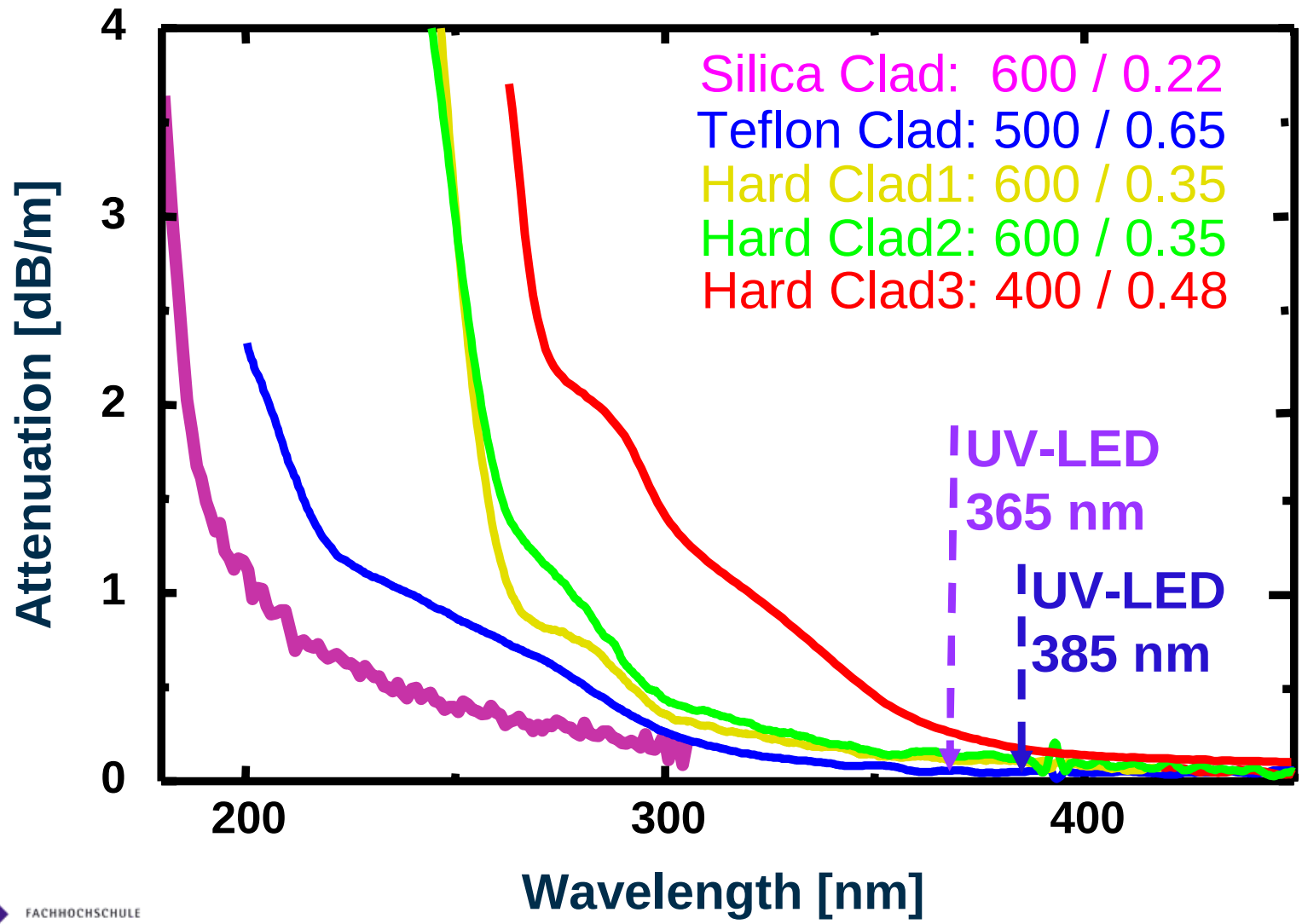
Spectral attenuation of „other“ UV-fibers



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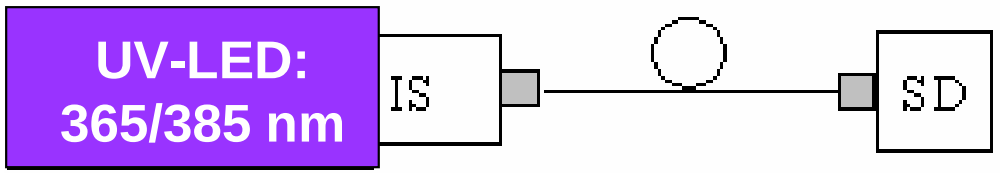
Test systems for UV-transmission changes due to UV-LEDs light

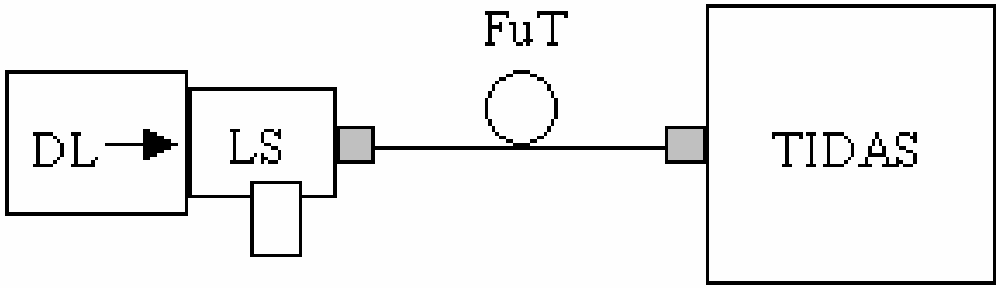


Fiber transmission changes during transportation of UV-LED light

Irradiation and material changes

Spectral testing

Fiber transmission using a broadband deuterium-lamp and spectrometer (190 nm to 600 nm)



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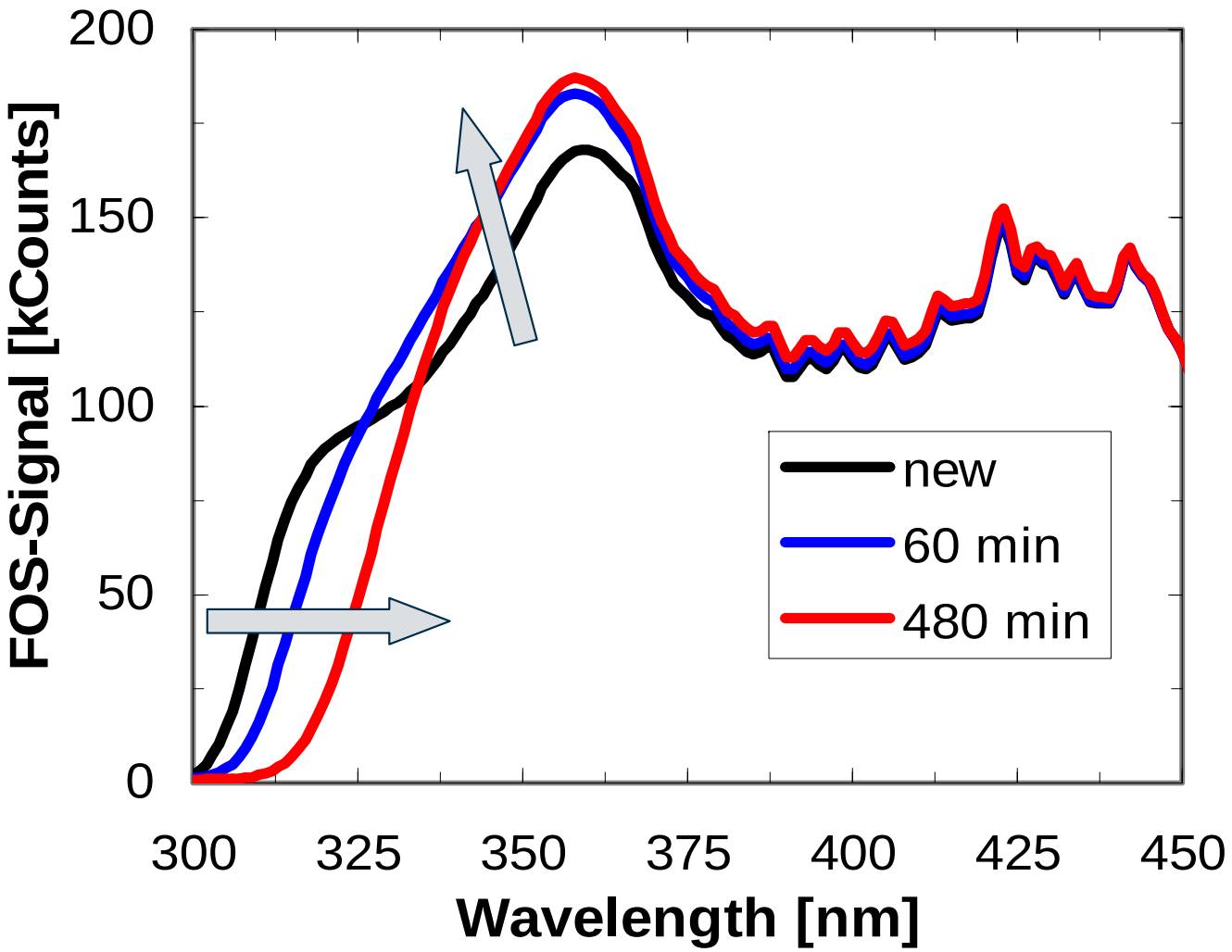
Spectral output signal of POF1000



„Old“ UV-LED
Input power:
≈ 35.0 mW

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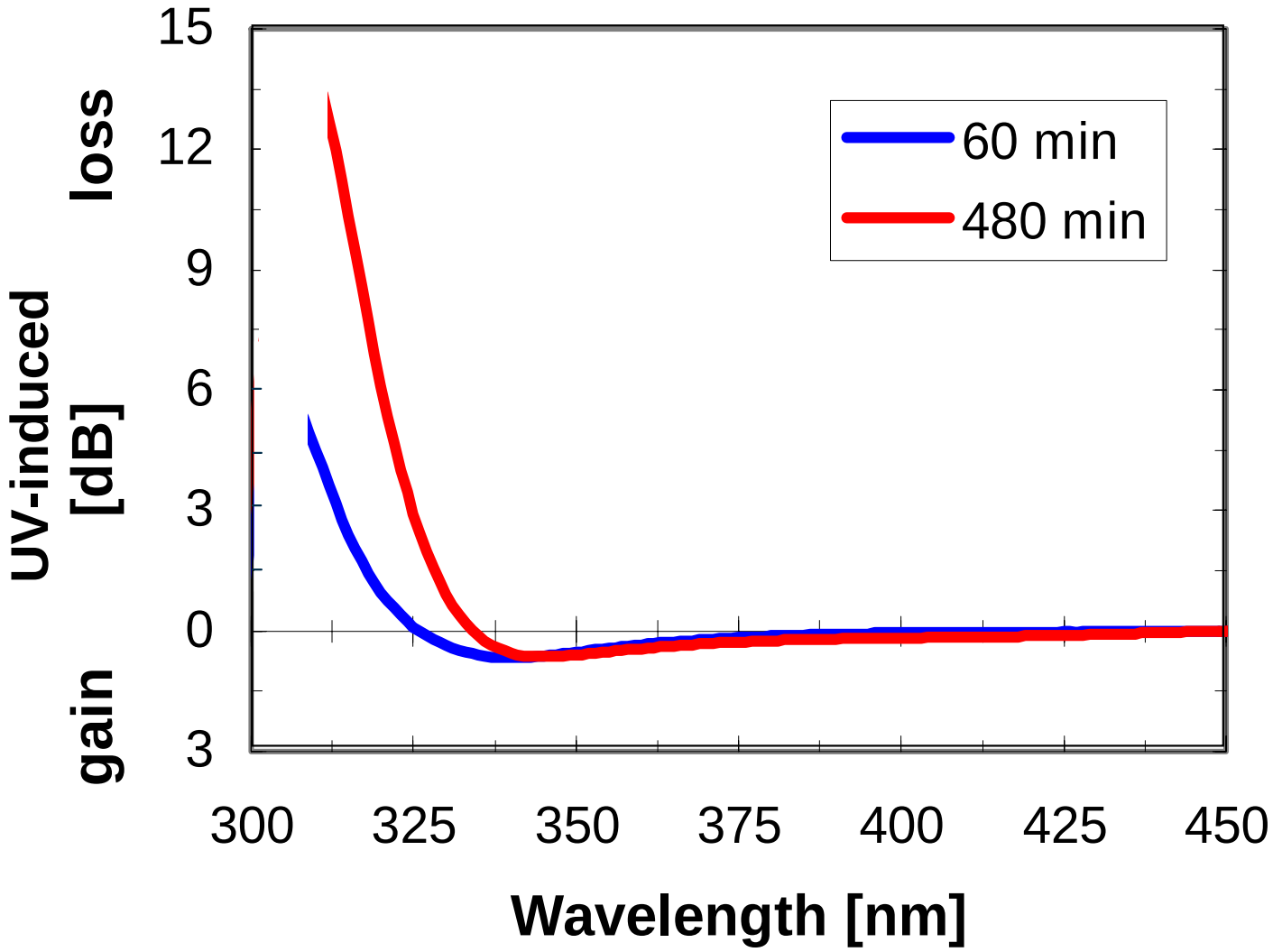
Spectral transmission changes (gain/loss) of POF1000



„Old“ UV-LED
Input power:
≈ 35.0 mW

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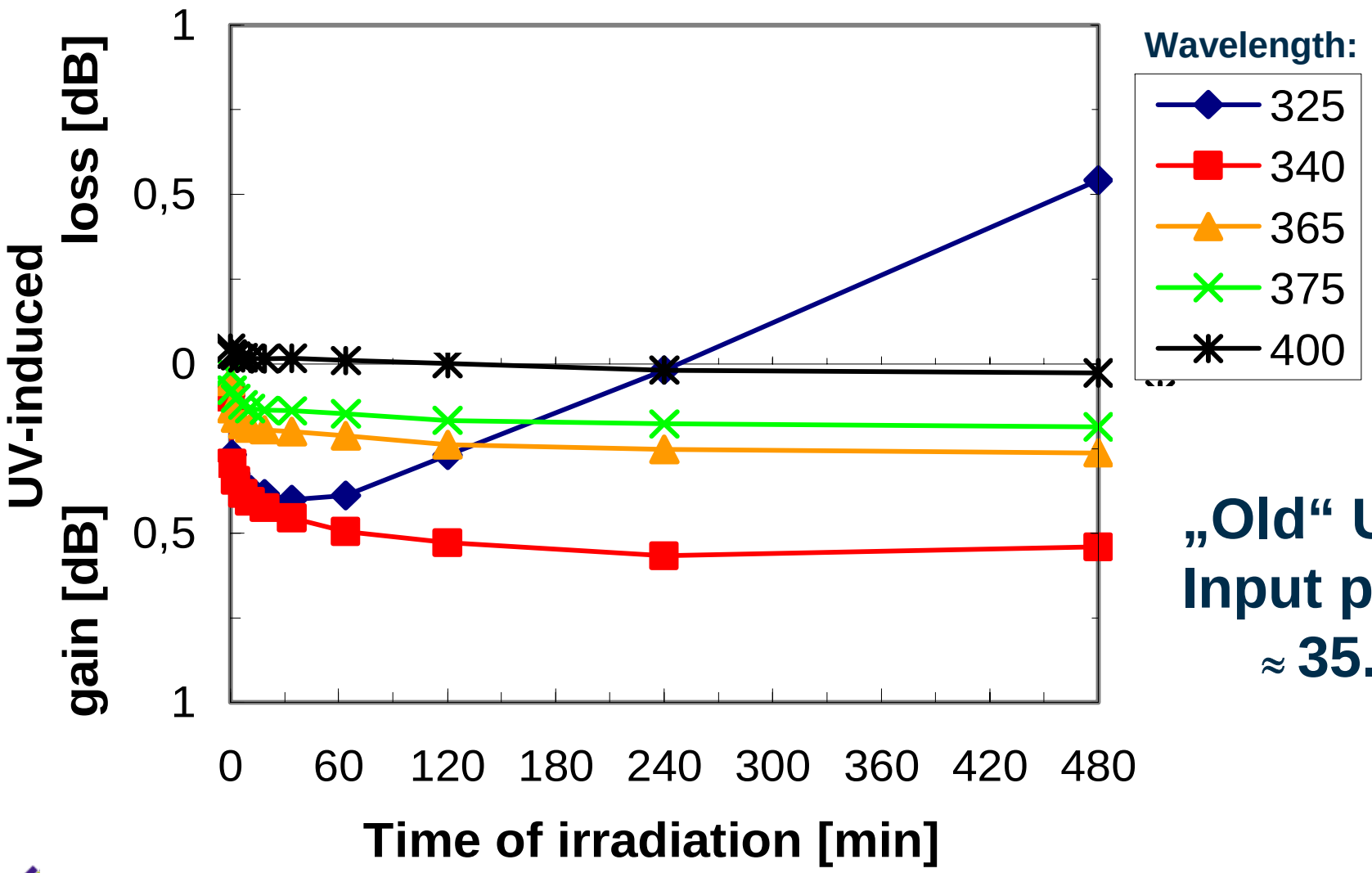
Temporal transmission changes of 1000 µm POF, at different UV-wavelengths



„Old“ UV-LED
Input power:
≈ 35.0 mW

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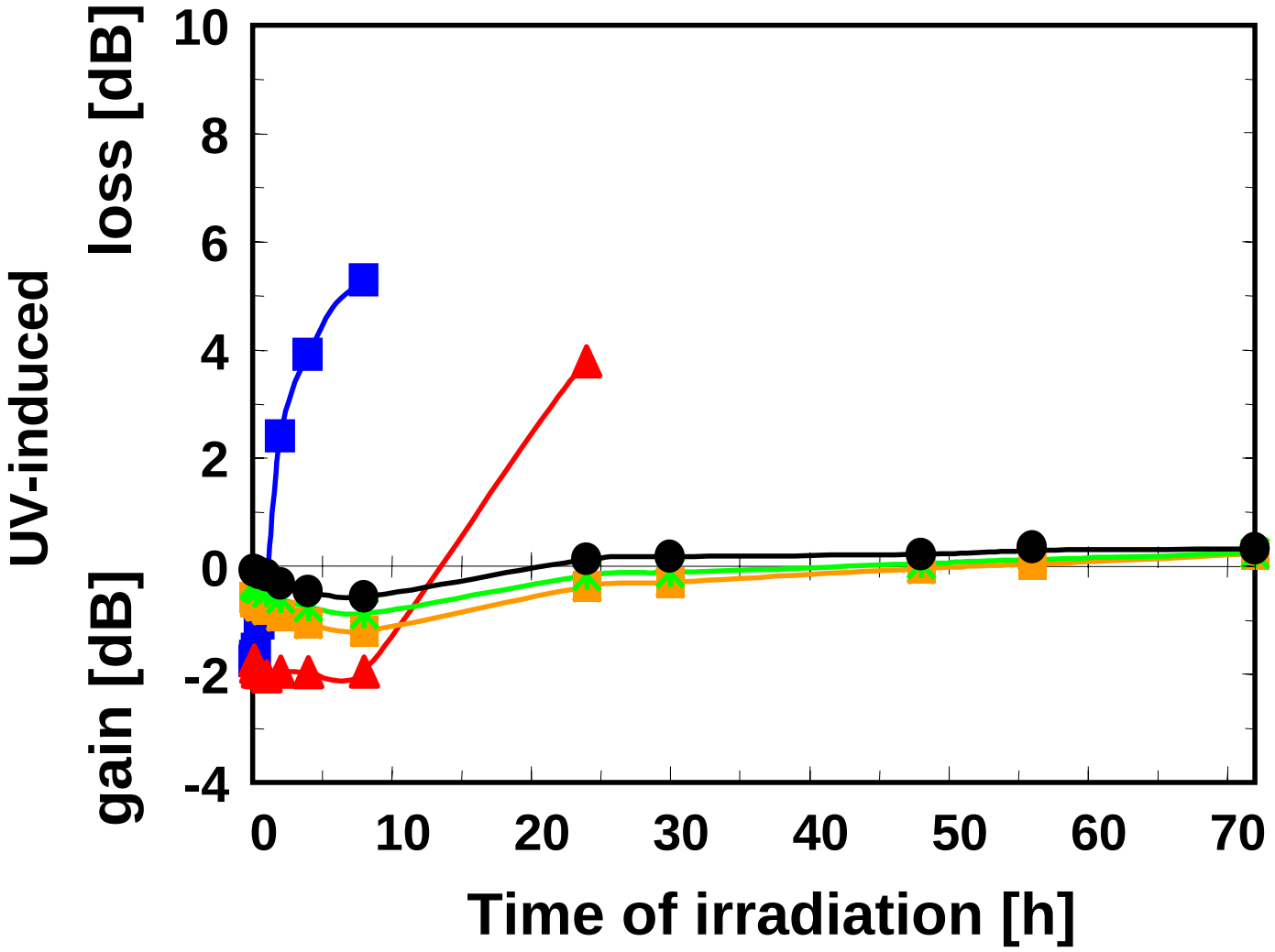
Temporal transmission changes of 1000 µm POF, up to 3 days



„Old“ UV-LED
Input power:
≈ 35.0 mW

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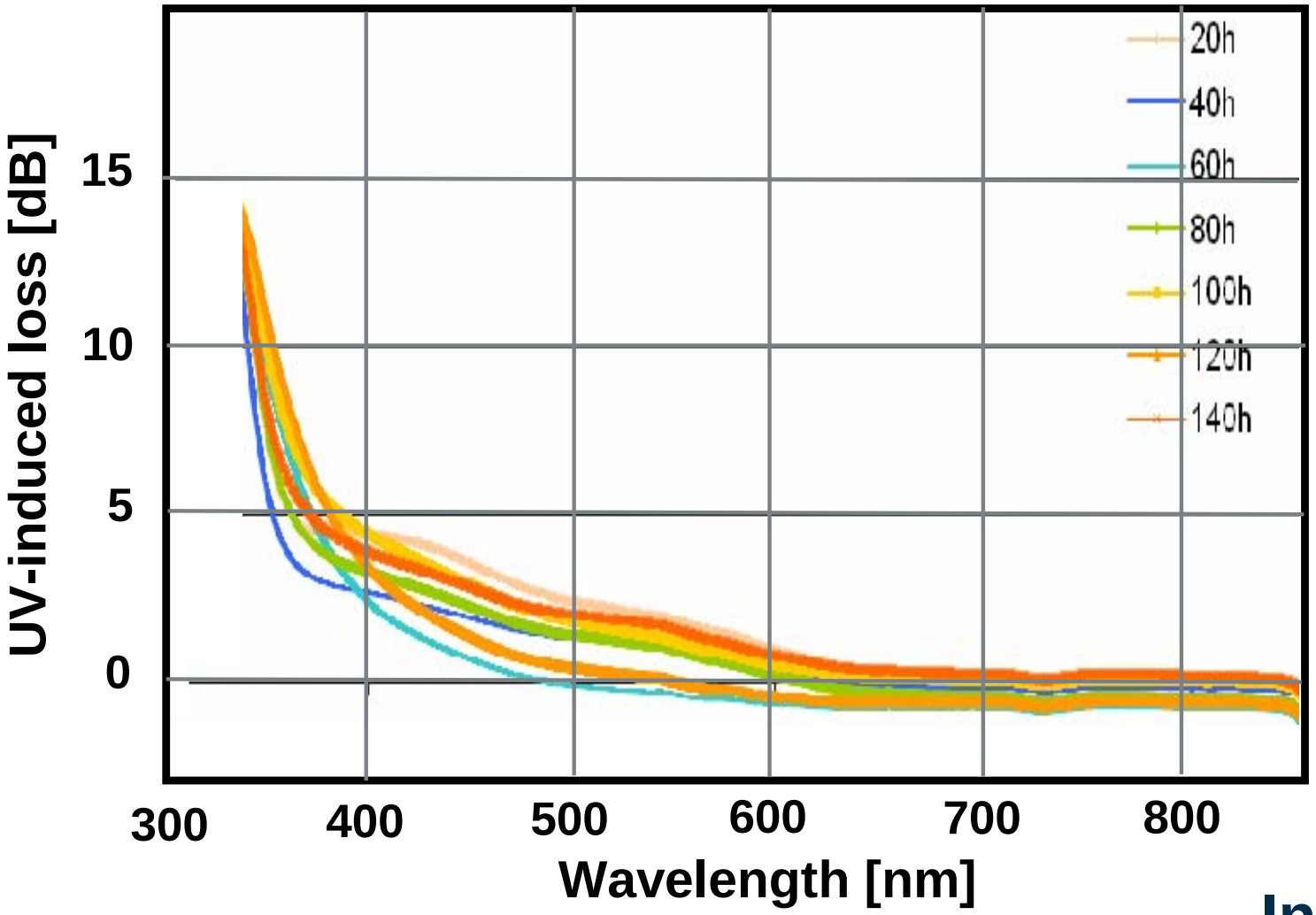
Spectral changes of 1000 µm POF, with 365 nm UV-LED up to 6 days



Length:
2.0 m

Input power:
≈ 70.0 mW

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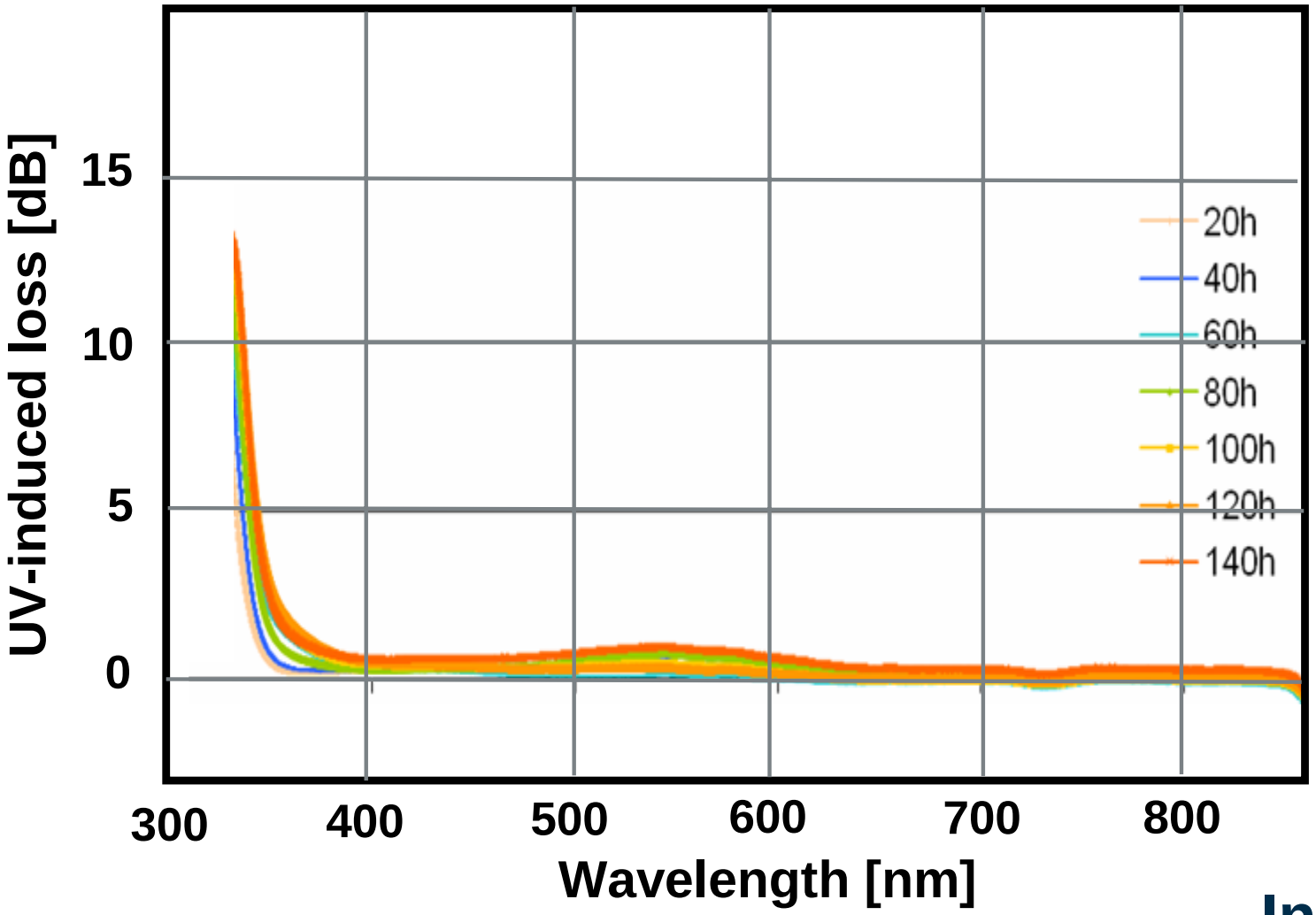
Spectral changes of 1000 µm POF, with 385 nm UV-LED up to 6 days



Length:
2.0 m

Input power:
≈ 70.0 mW

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Comparison of UV-induced loss of POF, due to UV-LEDs after 12 days

Test wavelength

Wavelength of irradiation	365 nm	385 nm
365 nm	11.3 dB	5.3 dB
385 nm	4.0 dB	0.6 dB

Length:
2.0 m

Input power:
≈ 70.0 mW

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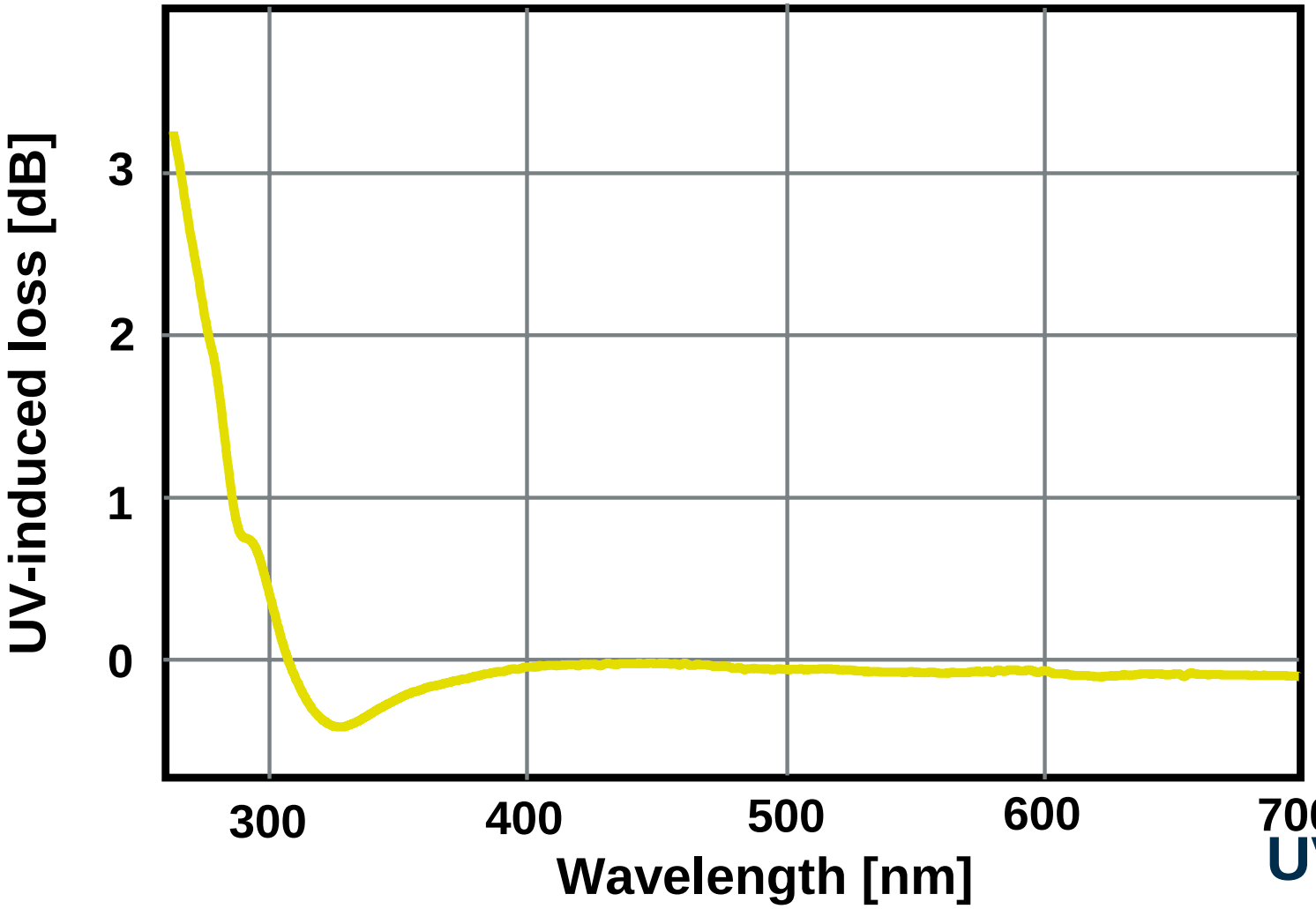
Spectral changes of 600 µm PCS2, with 365 nm UV-LED up to 8 days



Length:
1.0 m

NA: 0.35

UV-LED
Input power:
≈ 25.0 mW

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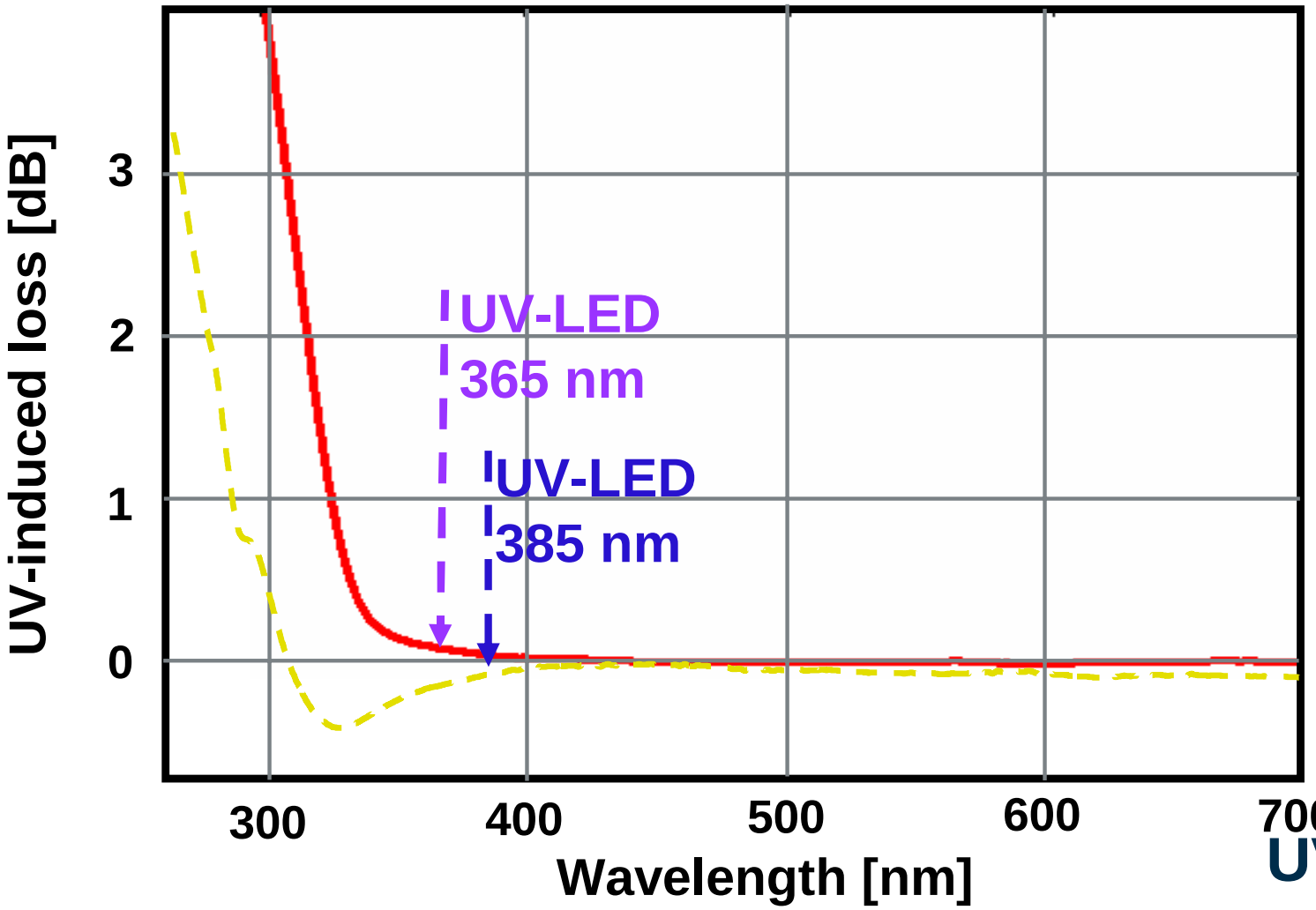
Spectral changes of 400 µm PCS3, with 365 nm UV-LED up to 6 days



Length:
1.0 m

UV-LED
Input power:
≈ 25.0 mW

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Evaluation

	AS-Fibers	PCS 0.35	PCS3 0.48	Teflon-clad	POF 1000	POF 2000
Costs	-	+	+	-	+	+ +
Flexibility (incl. bundle)	0	+	+	+	+ +	+ +
Bending loss	- -	0	+	+ +	+	+
Life-time	+ +	+	+	+ +	- -	- -
Coupling-efficiency	- -	0	+	+ +	+	+ +
Handling	0	0	0	- -	+	+
Length	> 10 m	< 10 m	< 5 m	> 10 m	< 2 m	< 2 m

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Summary and outlook

- Study of a „flexible“ lightsource in UV-A region,
  based on UV-LEDs and optical fibers
- Total power output, depending on
  aspect ratios
  numerical aperture of (mono) fibers
  cross-section area (mono-fiber vs. bundle)
  basic and UV-induced losses of fiber
- Transmission and stability of POF at 365nm:
  Product with POF for R&D available, POF disposal
- Study of life-time of PCS-fibers to be completed;
  important for industrial applications
- New materials or structures: to be tested
- New UV-applications

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